AD NUMBER	
AD016455	
CLASSIFICATION CHANGES	
TO:	**unclassified**
FROM:	**confidential**
LIMITATION CHANGES	
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AUTHORITY	
ARRADCOM ltr, 4 Sep 1981; ARRADCOM ltr, 4 Sep 1981	

A.D. 164558

CONFIDENTIAL

TWENTY-FIRST

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

105 MM BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-019-ORD-33 (Negotiated)
RAD ORDTS 1-12383

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio

APRIL, 1952

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ABSTRACT

The status of each rifle manufactured is reviewed. A small design change in the vent ring, as indicated by conditions after firing 300 rounds, is described and illustrated. The results of measuring five chambers for volume are given.

A lot of 50 T-138 E57 HEAT projectiles were sent to Arms and Ammunition Proof Section of Aberdeen Proving Ground for tests of safety and performance. Detailed results of these tests are presented.

There are no firings with the T-171 projectile to be reported this month.

In the design of the T-119 projectile the possibility of using die cast component parts, where possible, has been investigated. The results of the tests conducted with cast fins and cast housings are described. The results of firing the T-119 projectile from a howitzer are discussed.

Penetration tests conducted with semi-cylindrical liners and with tapered wall conical liners are described and the results are given.

Tests conducted with the T-222 E3 fuze system are described and the results are discussed. Tests with the T-267 electrical HE fuze are reported.

THE RIFLE

It was reported in the Eighteenth Progress Report that six T-137 El rifles and two complete sets of spare parts had been manufactured in addition to two T-137 El rifles manufactured earlier to evaluate the design. The present status of these units is as follows:

The T-137 El No. 1 rifle and the T-152 El mount are at Aberdeen Proving Ground for use in firing tests involving the T-171 projectile.

The T-137 El No. 2 rifle and a T-152 E2 mount are at Erie Ordnance Depot.

A T-137 El rifle and a T-152 E2 mount are at Fort Benning for Army Field Force evaluation. This rifle is equipped with a T-46 spotting rifle and a T-183 direct sight and is mounted on a jeep.

A second T-137 El rifle, T-152 E2 mount, T-46 spotting rifle and T-183 direct sight is at Aberdeen Proving Ground. This rifle chamber has been used in firing more than 300 rounds. After 300 rounds the chamber of this rifle was "Magnafluxed" and examined by X-ray. No evidence of damage to the chamber was found.

Two other T-137 El rifles and T-152 E2 mounts are being prepared for shipment to Aberdeen Proving Ground by May 12, 1952.

One T-137 El rifle is at Picatinny Arsenal where it is being used as a chambering gage.

The remaining T-137 El rifle components are being held in Akron pending completion of T-152 E2 mounts.

During the course of firing 300 rounds from the T-137 El rifle at Aberdeen Proving Ground, evidence appeared that there was excessive stress in the thin web section of the vent ring. Steps have been taken to correct this condition by increasing the thickness of this web. The I.D. of the thin section has been decreased from 6.250 to 6.060 (Figure 1).

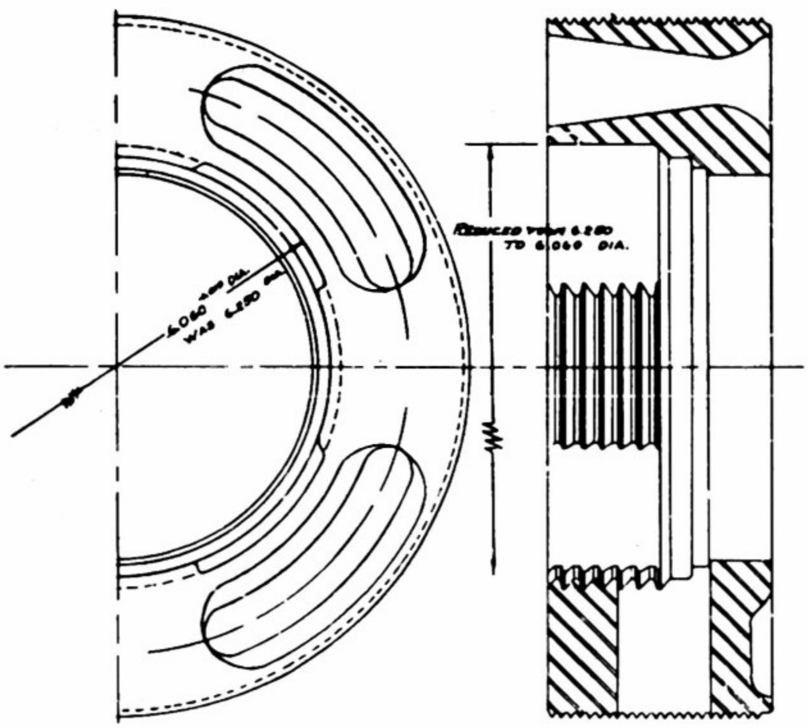

Fig. 1. Revision of Breech Ring.
Firestone Drawing No. DRD-206-19.

The volume of five T-137 El chambers was measured. The results are tabulated below:

Chamber Forging No.	Chamber Volume (cu in)
22B353SA	527.6
22B345EB	528.5
22B355TA	528.5
22B332UA	527.9
21B128C	528.3

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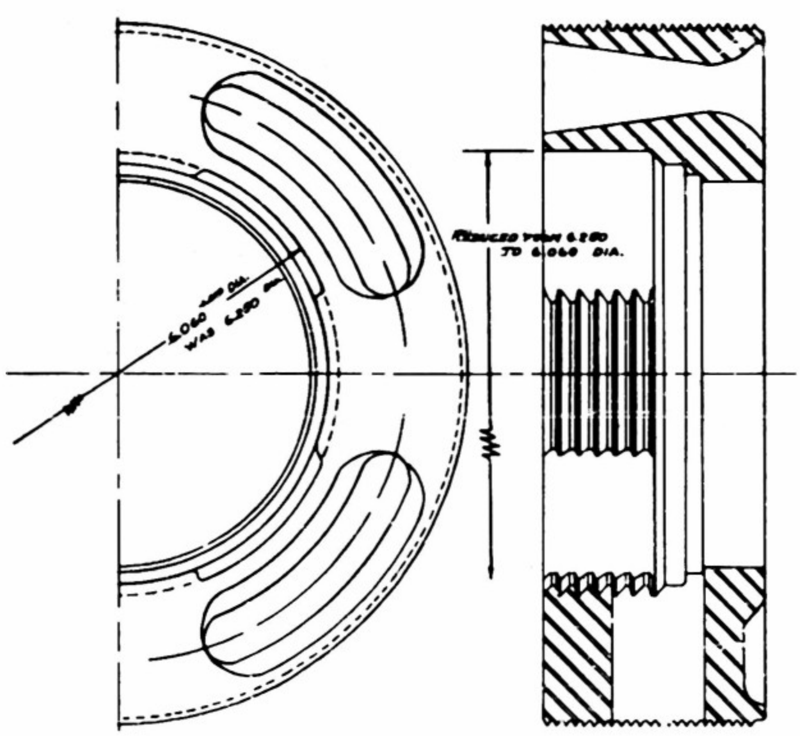

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T-138 E57 HEAT Projectile Tests at Aberdeen Proving Ground, Lot No. PA-E 9068

A lot of 50 T-138 E57 HEAT Projectiles was loaded at Picatinny Arsenal and sent to the Arms and Ammunition Proof Section of The Aberdeen Proving Ground for tests of safety and performance. The following paragraphs are a chronological record of the disposition of these rounds.

Test I

Five rounds, conditioned at 125°F, were fired against homogeneous armor plate inclined 60° to the line of fire. The range was 400 feet. Two of the five rounds functioned on impact and formed jets. The other three exploded but did not penetrate.

Test II

Two rounds, at temperatures of 70°F, were fired under the same conditions. One round formed a jet and one did not.

Test III

Ten rounds were removed from their shell cases and each was prepared for inspection by having the nose cap and the small base plug removed. The electrical continuity of the wiring was checked as well as the possibility of "shorts" between the wiring and the body of the projectile. The resistance of each base element was checked at the H.E. loading plant at Aberdeen and also at the time of firing, and was found to be between 100,000 and 200,000 ohms, which is acceptable. The fact that distortion of the crystal would produce an electrical potential was confirmed by using an electrometer. All ten rounds were fired against armor plate inclined at 90° to the line of flight. All ten rounds exploded on the target but none caused any penetration.

Test IV

Four rounds were removed from the shell cases and inspected electrically. After the resistance washers were removed these rounds failed to produce penetrations when fired against armor plate set at 90° to the line of flight.

Test V

Four rounds were fired, as received from Picatinny Arsenal, through a wooden bursting screen set 24 inches in front of the armor plate. The screen was 4 inches thick for the first 3 rounds and 6 inches thick for the last one of the group. The first round functioned against the bursting screen and gave a penetration of 4-6 inches in the armor plate set 24 inches back of the bursting screen. The remaining rounds went through the wooden bursting screen and exploded against the armor plate causing slight impressions but no penetrations.

Test VI

Ten rounds were disassembled and tested electrically. All defects were corrected. The base elements were replaced by elements from a different lot (PAE 8410). Five of these rounds were fired against plate set at 90° to the line of fire, but all rounds failed to penetrate.

Test VII

Two rounds were disassembled by removing both base plugs, and the T-208 base elements. Inspection showed radial cracks in the Comp. B. The Comp. B was approximately 1/16 inch below the shoulder of the seat for the base plug (appeared to be undercut). Jarring of the projectile by dropping it several times through a distance of 1 ft on to a 1 inch pine board made it possible to remove the Comp. B

charge. For the two rounds thus examined, there was definite evidence of two pourings. There was a layer approximately 1 inch thick which was not homogeneous with the main body of the H.E. The lead wire for the fuze offered definite resistance to the charge removal, but it did break at a point near where it came through the cone after repeated jarring. The insulation was found to be undamaged anywhere in the projectiles.

Test VIII

Nine rounds were removed from their shell cases and prepared for firing into a recovery box as follows:

(1) Each of three rounds had the small base plug removed and the base element removed and inerted by removing the tetryl pellet, tetryl lead, and the T-18 detonator. The inerted base element was replaced in the round, the wiring was checked for continuity and freedom from shorts to the body and the small base plug was replaced. Reference marks were made between the Comp. B and the large base plug, and between the base plug and the body.

(2) Three rounds were prepared as in (1) but, in addition, the large base plugs were tightened into position with an 18 inch wrench.

(3) The remaining three rounds were prepared as in (1) but, in addition, the large base plugs were removed and the felt shock pads were replaced by rubber pads .125-inch thick. The base plugs were tightened into position with an 18 inch wrench.

Eight rounds were examined after recovery. One round was completely disassembled. The following observations were made:

1. Each of three projectiles had a short between the fuze wire and the body which was eliminated by removing the wire from the base element (i.e. the terminal of the base plug shorted against the rotor when decelerated).

2. All wires were found to be continuous after recovery.

3. There was no rotary movement of the Comp. B or the base plug in any of the rounds.

4. In one round the Comp. B was set forward a measured distance of 1/4-inch and in all of the others that were examined the Comp. B was found to be set forward by a similar distance.

5. The cone in the round that was completely disassembled was distorted slightly. X-ray examination of three other rounds showed some distortion in each of the cones.

6. The nose caps of seven of the eight projectiles were loose and could be unscrewed by hand.

7. The crystal element was crushed to a powder in each case.

8. None of the cambric insulators in the nose elements were punctured and were judged to have been effective in preventing shorting at the nose.

9. The nose caps were cupped in front and in nearly all cases were bulged on the sides.

Test IX

Four rounds were inspected and reassembled with .125-inch rubber shock pads replacing the felt pads between the large base plugs and the Comp. B and between the T-208 base elements and the Comp. B. These rounds were fired against plate set at 90° to the line of fire and failed to cause penetration.

The remaining five rounds of the fifty rounds are being held for inspection and further tests. Two are at Picatinny Arsenal and three are at Aberdeen Proving Ground. X-ray examination of the three rounds at Aberdeen Proving Ground has not shown any possible cause for failure.

Additional tests with additional T-138 E57 HEAT rounds are planned in an effort to locate and correct the cause of the malfunctions. The tests with similar rounds, presented in the Sixteenth Progress Report, show that this round is capable of good performance.

T-171 PROJECTILE

There were no firings with the T-171 projectile during the month of April.

T-119 PROJECTILE

During the development of the T-119 projectile, much attention has been directed toward designing for low cost production. A potential means for reducing the cost of the aluminum tail components of the projectile exists in the use of die castings, provided such castings can be made sufficiently strong.

To test the strength of such castings, samples of die cast fins and a sand cast housing, to simulate a die casting, have been subjected to firing tests. The cast fins and the housing were tested in separate projectile assemblies which were fired through yaw cards into a recovery box.

The casting failed in each case; the fin failure consistently occurred at the gear form, but the housing broke into several large fragments. Consideration is being given to strengthening the fin in the hinge section by using a steel insert, but a die cast housing does not appear to be suitable. However, additional projectiles incorporating cast housings will be fired.

In a severe strength test, a T-119 projectile was fired from the 105mm Howitzer, M2A1. Signs of fragments were found in a yaw card placed near the gun muzzle. The recovered fragments indicated that the initial failure was caused by collapse of the projectile gas chamber. (See DRB 168, Figure 2). A simple strengthening of this chamber should result in a projectile capable of surviving howitzer launching.

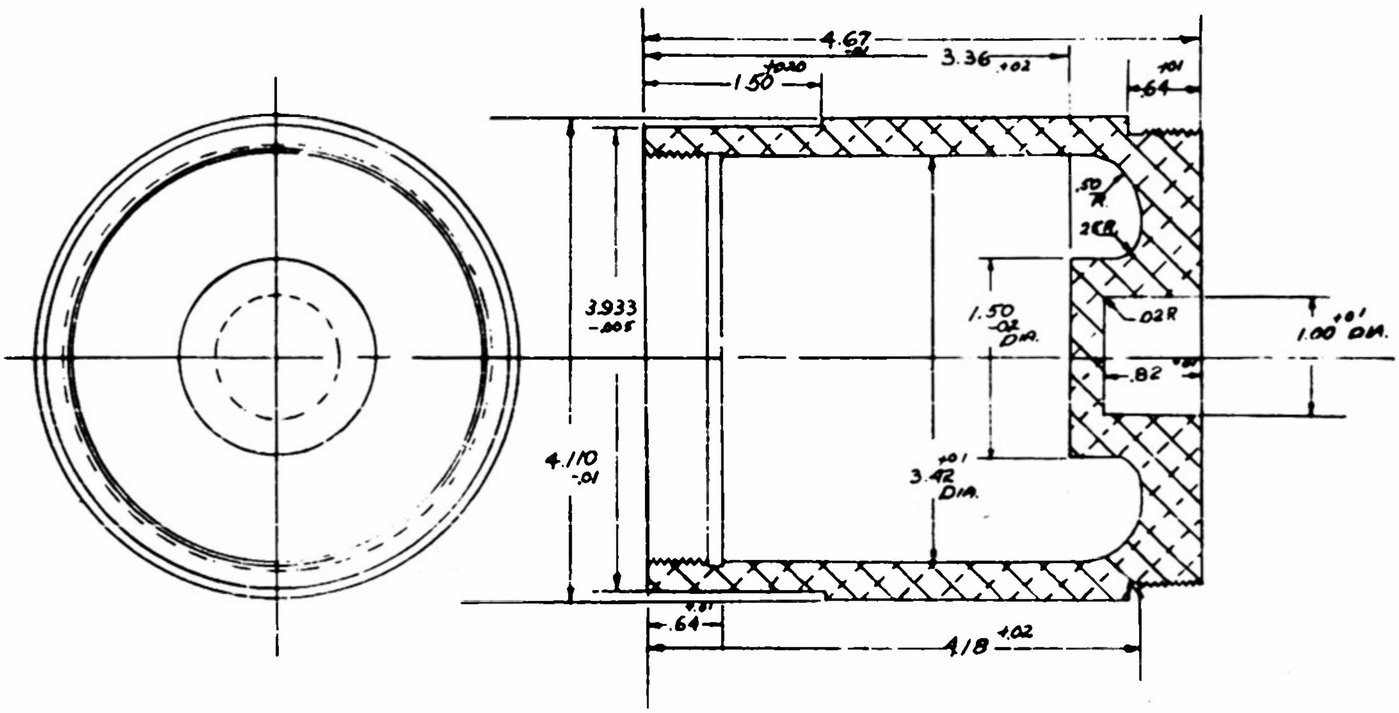


Fig. 2. Projectile Gas Chamber.
Firestone Drawing No. DRB 168-3.

Die Cast Fin Tests

Projectile number 45 was assembled with die cast fins. This projectile was fired through three yaw cards into the recovery box. Recovery of the projectile revealed that each of the fins had broken in a very similar way, at the gear form. One recovered fin is shown as "a" in Figure 3. Inspection of the yaw cards indicated that the fins had broken under the rapid deceleration of the opening action, had over-traveled, and then had returned to their correct positions before entering the recovery box. Since the failure seemed to be caused by impact deceleration, a Riehle pendulum impact tester was modified to accomodate the fin. The complete tester, with pendulum in the raised position, is shown in Figure 4. Figure 5 shows the fin in the test fixture about to be struck by the pendulum. Several fin designs were tested in this machine for impact strength. The data are shown in Table I.

The first group of fins (see fin "b" of Figure 3) were die cast and differed from those fired with projectile number 45 only in that the fins were shortened to fit the test apparatus.

In an effort to improve the strength of the casting, die cast samples were made with the following modifications:

1. A larger radius was added at the root of the gear form to reduce stress concentrations.

2. The gear form was die cast and broached to the final tolerance to avoid sharp tool marks.

3. The flat portion of the fin was milled over the region of the hinge pin hole only to preserve as much of the high strength skin as possible.

While modifications resulted in a minor improvement over the original casting, the impact strength was still considerably below that of fins milled from 24ST-4 aluminum plate. Consideration is being given to the use of a steel insert in the region of the failure.

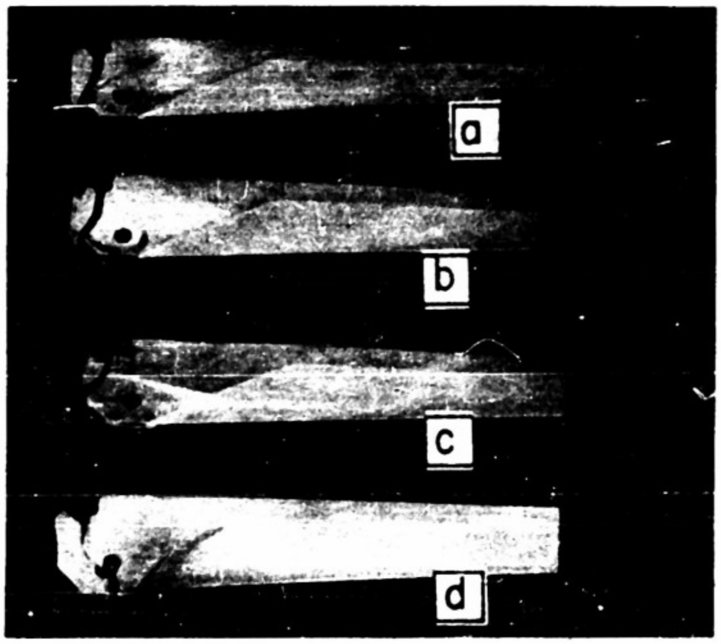


Fig. 3. T-119 Projectile Fins.
Test samples showing typical impact failure. Fins "a," "b," and "c" are A360 aluminum die castings and "d" is a fin milled from 24 ST4 aluminum plate.

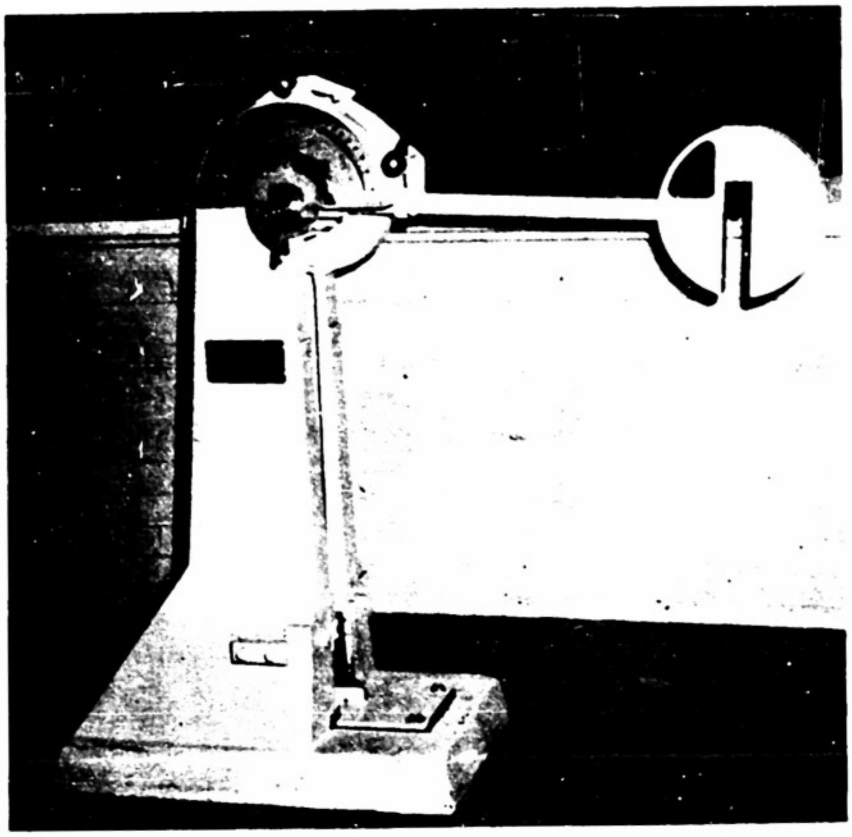


Fig. 4. Modified Impact Tester.
Note special fixture for holding fin.

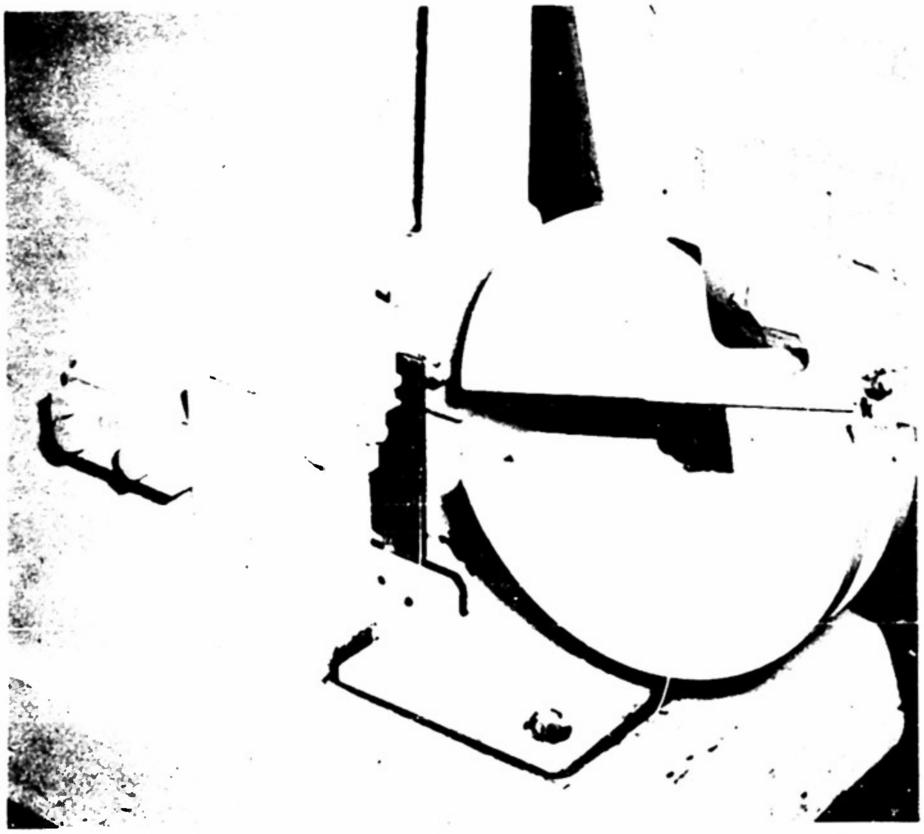


Fig. 5. Close-Up of T-119 Projectile Fin Impact Test.

Table I

Impact Strength of Fins for T-119 Projectile

Drawing No.	Fin Description	Breaking Energy (ft-lbs)
DRB418-3	*Die cast - milled gear form and flats	7
DRB418-3	" " " " " " "	5.5
DRB418-3	" " " " " " "	6
DRB418-3	" " " " " " "	7.5
DRB418-3	" " " " " " "	7
DRB418-3	Die cast, anodized - milled flats, partly milled gear form	9
DRB418-3	" " " " " " " " "	10
DRB418-3	" " " " " " " " "	8
DRB418-3	*Die cast - Cast and Broached gear form - flats	10
DRB418-3	milled over region of hole only.	12
DRB418-3	Die cast - small cast gear form - not milled on flats	6
DRB418-3	" " " " " " " " " "	7
DRB418-3	" " " " " " " " " "	10
DRB49-6	Machined from 24ST4 plate	65
DRB49-6	" " " "	75
DRB49-6	" " " " . Gear form notched	54
DRB49-6	Modified for 20 min. cant (Fin bent under impact due to lack of symmetry).	122.5

*Shown in the photograph in Figure 3.

Firing Tests With a Cast Housing

To obtain an estimate of the suitability of an aluminum die cast housing, a sand casting was made in accordance with DRC 284 and assembled in projectile number 164. The sand casting alloy 195-T6 was selected because it most closely approximates the properties of the die casting alloy A360 intended for this application. The loading and firing procedures were described in the Nineteenth Progress Report, Table XIII. The housing failed when the projectile was fired and the recovered fragments are shown in Figures 6 and 7.

The evidence seems to indicate that the failure occurred soon after the projectile left the muzzle and that the failure was caused by the sudden reversal of the pressure differential at the projectile chamber at muzzle exit. This conclusion is supported by the lack of projectile

fragment marks in the gun tube, by the signs of separation in the first yaw card (Figure 8), and the shape of the fragments recovered. Additional tests are planned but it does not appear probable that a satisfactory housing can be made by die casting.

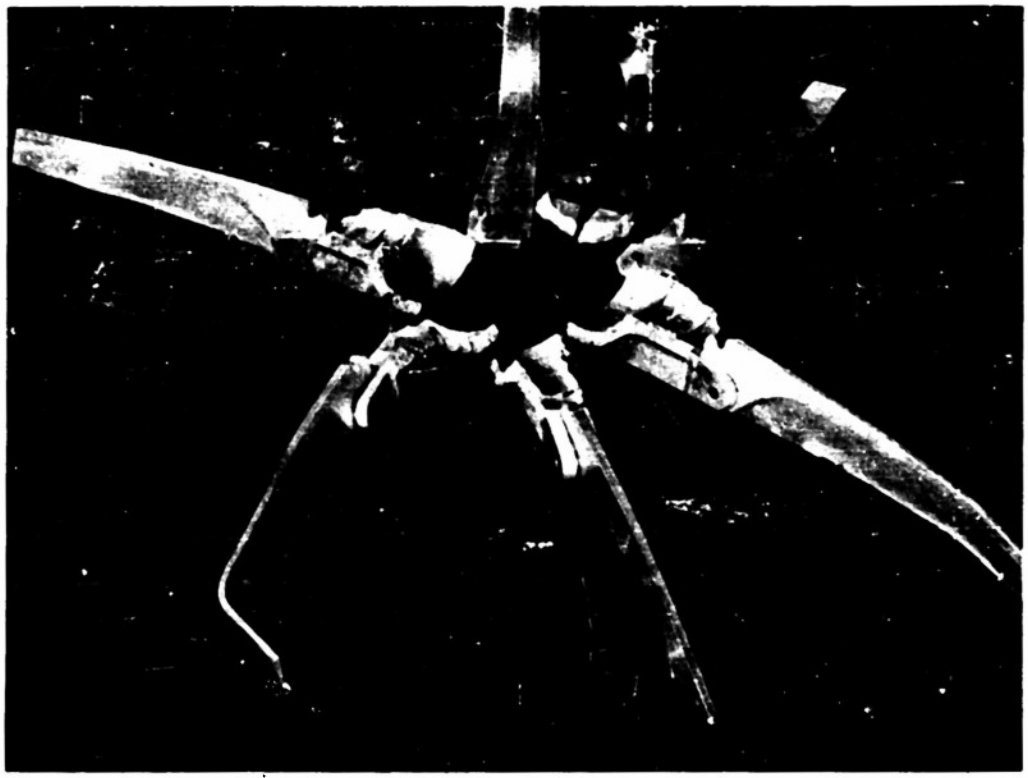


Fig. 6. Sand-Cast Housing From T-119 Projectile.

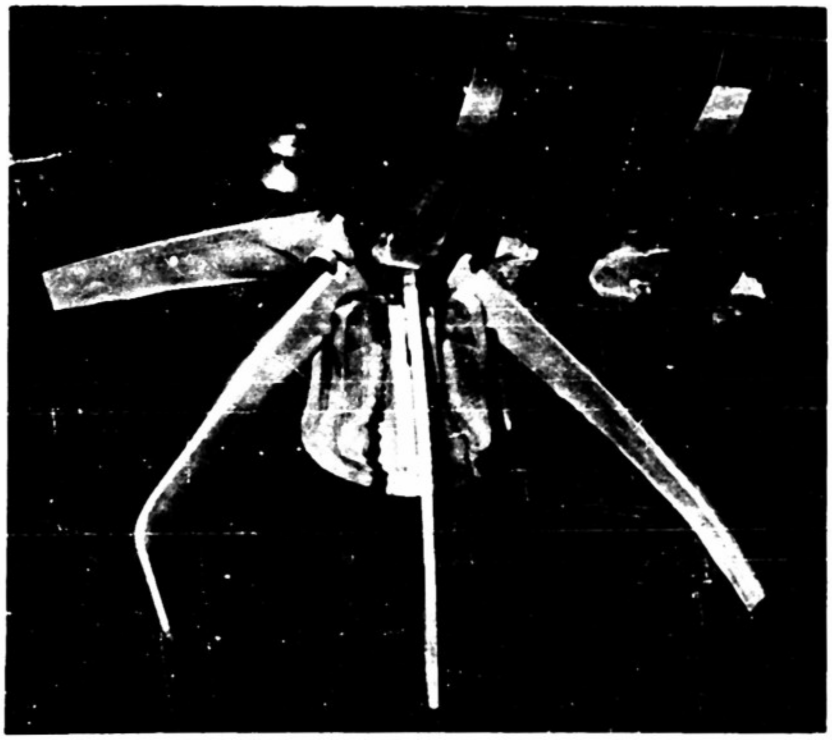


Fig. 7. Sand-Cast Housing From T-119 Projectile.

Fig. 8. First Yaw Card.
T-119 Projectile with Cast Housing.

Firing of the T-119 Projectile From a Howitzer

The successful firing of the T-119 projectile, from a recoilless rifle having a tube rifled one turn in 20 calibers (Twentieth Progress Report), suggested the possibility of firing this projectile from a 105mm howitzer. The range data for such a test, including a charge development, are given in Table II. A plot of the charge development data is given in Figure 9.

When projectile number 64 was fired from the howitzer it broke apart but the pieces were recovered. An examination of the recovered fragments and of the yaw cards indicated that the projectile gas chamber collapsed in the gun from the pressure of the propellent gases. The recovered fragments are shown in Figure 10 and the first yaw card is shown in Figure 11.

Since all components, with the exception of the chamber, appeared to survive the launching in good condition, it is felt that a 105mm T-119 projectile can be made to successfully withstand the higher pressures of a howitzer by simply strengthening the projectile gas chamber.

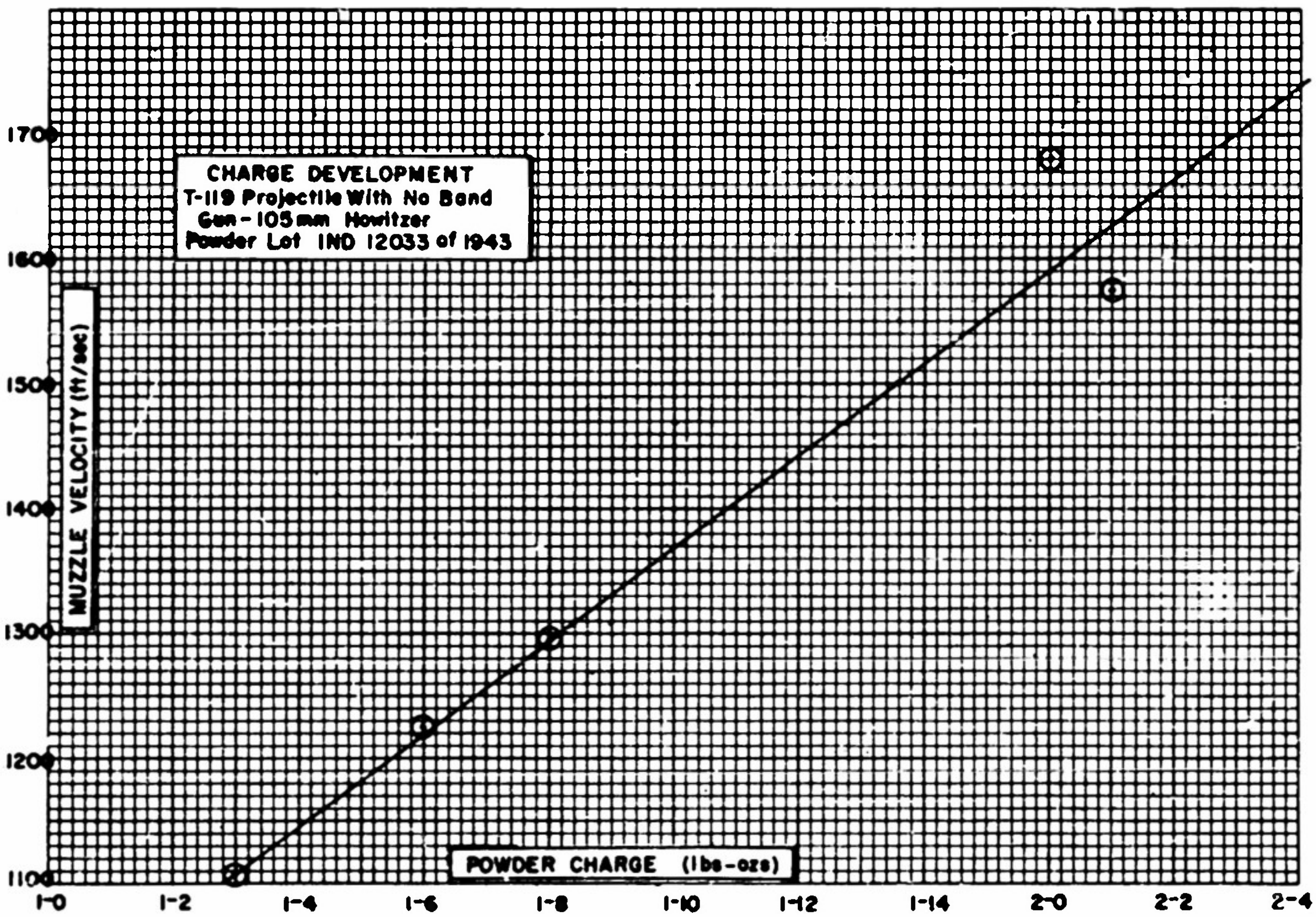


Fig. 9. Charge Development Data.
Powder Charge Versus Muzzle Velocity.

Fig. 10. Recovered Fragments of T-119 Projectile.
Fired from 105mm. howitzer, M2A1.

Fig. 11. First Yaw Card for T-119 Projectile.
Fired from 105mm. howitzer, M2A1.

Future Program

1. Components for 30 T-119 projectiles have been received and are being assembled. A portion of these projectiles will be live-loaded for a combined accuracy and penetration test.

2. The manufacture of a pilot lot of 500 T-119 production-type projectiles is continuing. Tentative plans call for the use of forged aluminum fins with these rounds.

Table II

Range Data for T-119 Projectile

Fired from 105mm. howitzer, M2A1

Tube Rifled 1-20

Date April 24&25 Program T-119 C-2

Time:
Start: ______
Stop: ______

PROJECTILE
Model T-119
Type Slugs & Projectiles
Weight (Nominal) 17.50 lb.
C.G. Location ______
Bourrelet Dia (Nom.) 4.120 -.003 in.
Special Features ______

COMPONENTS
(Projectile No. 64)
Nose - Blunt
Body - DRC 111-1
Chamber - DRB 168
Housing - DRB 169
Piston - DRB 65
Stop - DRB 66
Fins - DRB 49-6
Piston Orifice Dia. -.359 in.

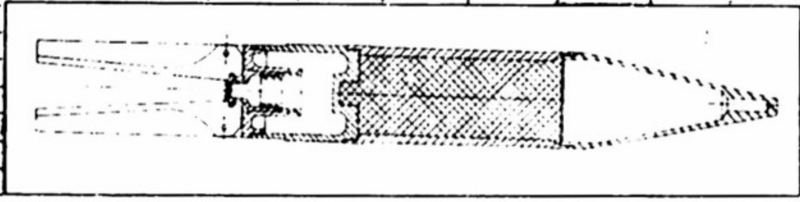
TEST GUN
Model 105 mm Howitzer
Type M2A1
Length of Tube 81.67 in.
Twist of Rifling 1-20
Sighting Equipment ______
Bore Dia. (Lands) 4.134 +.003 in.

MISCELLANEOUS DATA
Range Recovery Box
Propellant
Type ______ web S.P. Charge wt. Variable
75mm Howitzer IND 12033 of 1943
Proof Director E. Huffman
Observers Hoff, Engebretson, Brown.

Round No	Time of Flight	Proj. Weight	Powder Charge lb - oz	Wind Vel. & Dir.	Chamber Pressure (lb/sq.in)	Muzzle Velocity Instr.[A]	Muzzle Velocity Actual[B]	Elev. (mils)	Time milliseconds	Remarks
1 - slug		17.60	1 - 0		6,200	1070	1094		58.17	Banded slug for warm-up. All other slugs have no bands.
2 - "		16.95	1 - 3		Low - not on chart	1086	1109		58.05	
3 - "		16.96	1 - 6		12,300	1200	1224		52.86	1. LOADING CASE: The standard howitzer case was used. Pressure gauges
4 - "		16.96	1 - 8		12,800	1270	1294		49.66	were inserted into the case before loading the powder.
5 - "		16.97	1 - 11		8,800	—	—		—	2. LOADING GUN: Pressure gages were not used for the projectile to
6 - "		16.94	2 - 0		13,600	1655	1679		38.09	eliminate the possibility of the gages damaging the fins. The
7 - "		17.08	2 - 1		13,000	—	—		—	complete round was tipped with the projectile nose down prior
8 - "		17.06	2 - 1		12,800	1560	1574		40.69	to inserting into the gun
9 - "		17.05	2 - 3		12,800	—	—		—	3. OBSERVATIONS:
10 - "		17.04	2 - 3		13,300	—	—		—	a Slugs: At the higher powder charges the slugs appeared
11 - "		17.02	2 - 3		—	—	—		—	to tumble between the two velocity coils, and as a result
12 - "		17.02	2 - 4		21,000	—	—		—	no velocities were obtainable.
13										b. Projectile: No velocity screens were used. The powder
13 - 64		17.56	2 - 3		—	—	—		—	charge was determined from a plot of charge versus
										muzzle velocity. The yaw cards indicated that the projectile
										chamber collapsed prior to the first card

A. Screen distances: Muzzle to 1st, 27 ft. 5 in; 1st to 2nd, 63 ft.;
2nd to recovery box 25 ft. 9 in.

B. Using a retardation of .40 ft/sec/ft.



Center of Impact ______
Probable Error - Vertical ______
Probable Error - Horizontal ______

Semi-Cylindrical Liners (DRB 85)

The Eleventh Progress Report contains penetration data for three series of copper liners having cylindrical sections. Although none of these liners were found particularly promising some additional tests with one design, DRB 85, have been completed. Two conclusions of interest have been made, namely: (1) The effect of standoff distance upon penetration is negligible for all distances from 4.0 inches to 20.0 inches; (2) The loss in penetration caused by rotation is less than for well designed conical liners, but is consistent with the loss predicted by the correlation based upon the non-rotated penetration which was presented in the Eleventh Progress Report.

Experimental

Figure 12 shows the design of the DRB 85 liner used in this study. All liners were assembled in DRC 15-8 test assemblies, loaded at Ravenna Arsenal and tested for penetration into mild steel target plates (7 inches square and 3 inches thick) at Erie Ordnance Depot. Table III shows the penetration at various standoff distances and Table IV shows the penetration at various spin rates at a 7.5 inch standoff. The spin rate penetration curve for these liners is compared with that of a DRB2-8 45° copper cone in Figure 13.

Discussion

The average non-rotated penetration of the DRB85 liner is 11.0 ± 0.5 inches of mild steel at all standoff distances between 4.0 and 20.0 inches. At a standoff of 1.0 inch the penetration drops to 9.8 inches. The penetration standoff curve for conical liners is not nearly so flat and it would appear that a standoff less than 4.0 inches might be used without causing a reduction in penetration. Unfortunately, an average penetration of 11.0 inches is much less than can be obtained with copper cones of similar base diameter.

As the rate of rotation increases the penetration decreases, but not nearly as rapidly as with a well designed 45° conical liner. The rate of loss of penetration is, however, proportional to the lower value of the non-rotated penetration, and the correlation between spin rate and penetration, presented in the Ele-

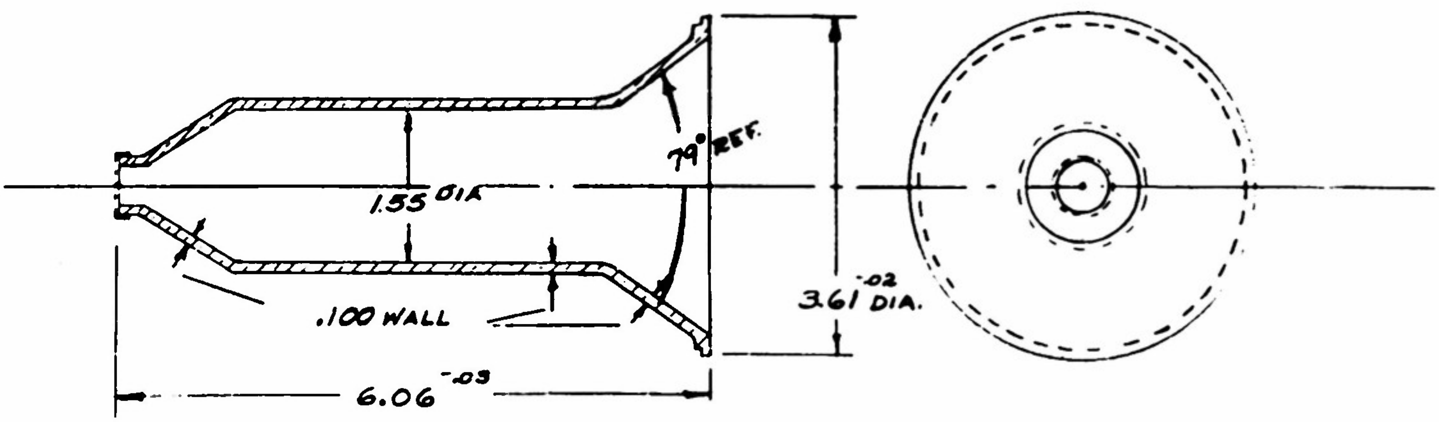


Fig. 12. Design of Semi-Cylindrical Liners.
Firestone Drawing No. DRB 85.

venth Progress Report, predicts the behavior of these semi-cylindrical liners quite well.

Because of the low level of penetration of the DRB85 liners, no further work with semi-cylindrical liners is contemplated.

Table III
Semi-Cylindrical Liners (DRB 85)
Effect of Standoff

Round No.	Rotation (Rev/Sec)	Standoff (inches)	Lbs.Comp B	Penetration (inches M.S.)	Max.Spread (inches)	Std. Dev. (inches)
FS416	0	1.0	2.30	9.69		
FS437	"	"	2.32	9.94		
FS438	"	"	2.38	9.88		
				Avg. 9.84	.25	--
FS398	0	4.0	2.38	10.31		
FS399	"	"	2.32	12.75		
FS400	"	"	2.32	11.62		
FS401	"	"	2.32	11.88		
FS402	"	"	2.34	10.88		
				Avg. 11.49	2.44	±.94
FS386	0	7.5	2.32	10.88		
FS387	"	"	2.34	8.62		
FS388	"	"	2.40	10.88		
FS389	"	"	2.26	12.69		
FS390	"	"	2.44	13.56		
				Avg. 11.33	4.94	±1.91
FS391	0	12.0	2.24	9.88		
FS392	"	"	2.40	14.38		
FS393	"	"	2.38	11.12		
FS394	"	"	2.30	9.69		
FS395	"	"	2.32	9.50		
				Avg. 10.91	4.88	±2.04
FS396	0	20.0	2.42	11.25		
FS397	"	"	2.36	9.62		
FS403	"	"	2.32	14.25		
FS404	"	"	2.36	9.18		
FS405	"	"	2.40	12.25		
				Avg. 11.31	5.07	±2.06

Notes: All rounds were assembled in DRC 15 test assemblies and were loaded at Ravenna Arsenal.

Table IV
Semi-Cylindrical Liners (DRB 85)
Effect of Rotation
Standoff - 7.5 inches

Round No.	Rotation (Rev/Sec)	Lbs. Comp B	Penetration (inches M.S)	Max. Spread (inches)	Std. Dev. (inches)
FS386-390	0	Table III	11.33	4.94	±1.91
FS432	+15	2.32	9.00		
FS433	"	2.32	11.94		
FS434	"	2.30	11.56		
FS435	"	2.32	12.06		
FS436	"	2.36	13.44		
		Avg.	11.60	4.44	±1.62
FS427	+30	2.34	12.18		
FS428	"	2.34	9.25		
FS429	"	2.36	11.69		
FS430	"	2.34	10.56		
FS431	"	2.38	9.75		
		Avg.	10.69	2.93	±1.25
FS422	+45	2.34	9.69		
FS423	"	2.32	10.44		
FS424	"	2.34	8.18		
FS425	"	2.32	9.69		
FS426	"	2.36	8.75		
		Avg.	9.35	2.26	±.89
FS417	+60	2.34	6.62		
FS418	"	2.32	7.06		
FS419	"	2.34	7.81		
FS420	"	2.36	4.81		
FS421	"	2.32	7.00		
		Avg.	6.66	3.00	±1.12
FS411	+90	2.32	5.88		
FS412	"	2.40	5.31		
FS413	"	2.36	5.06		
FS414	"	2.30	5.44		
FS415	"	2.34	4.56		
		Avg.	5.25	1.32	±.49
FS406	+180	2.34	3.12		
FS407	"	2.34	3.81		
FS408	"	2.40	2.94		
FS409	"	2.34	3.69		
FS410	"	2.40	3.44		
		Avg.	3.40	0.87	±.37

All rounds assembled in DRC 15 test assemblies and loaded at Ravenna Arsenal.

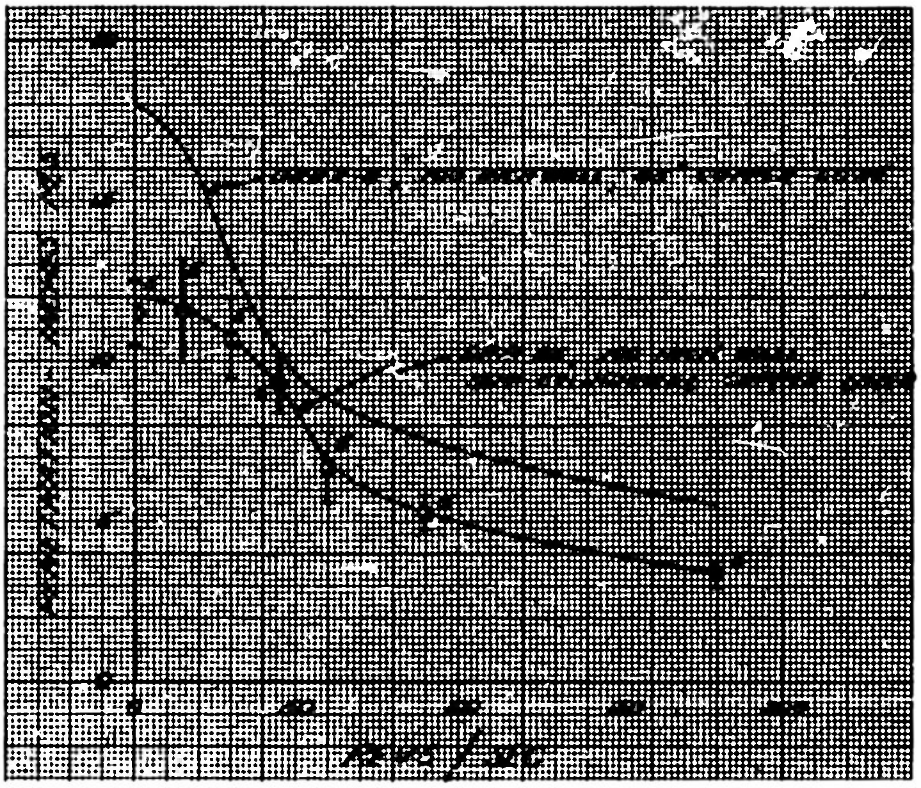


Fig. 13. Spin Rate - Penetration Curve.
DRB 85 Liners Compared With DRB 2-8 Liners.

Tapered Wall Conical Liners

All American and British service cavity charge liners have uniform walls. A large amount of experimental work has been done in various laboratories on the variation of the depth of penetration with changes in the design parameters of the liner. As a result of this experimentation, two conclusions regarding the effect of liner wall thickness are widely accepted, namely: (1) The optimum uniform wall thickness for a shaped charge projectile, as determined by the depth of penetration, is proportional to the diameter of the charge and liner; (2) With increased charge confinement, that is, with heavier projectile walls, the optimum wall thickness is increased.

Since the diameter of a cone varies uniformly from apex to base, the proportionality of optimum wall thickness with diameter expressed in (1) above suggests that a conical liner with a uniformly tapering wall would be superior to a liner with a uniform wall. On the other hand, the second conclusion of the preceding paragraph suggests that a heavier wall may be tolerated near the apex of a cone encased in a charge of large diameter than would be desirable for a similar cone section encased in a smaller diameter charge.

Tapered wall steel cones have been studied rather extensively.[1] These experiments with both 1.63 and 4.35 inches diameter charges failed to show that cones thinner toward the apex were superior to cones with uniform walls. There is, however, some British information to the effect that wall thickness taper from

1. "The Effects of Various Aberrations on the Performances of Cavity Charges", Washington, N.D.R.C., 3 Dec. 1945. (OSRD No. 5599) CONFIDENTIAL.

thin at the apex to thick at the base produces significant improvement in the case of 80° lead cones.[2]

It is shown in the Fourteenth Progress Report, Figure 12, that the optimum <u>uniform</u> wall thickness for a 45° copper cone (DRB2) encased in a DRC 15 test assembly and fired at 0 rev/sec and at a standoff of 7.5 inches is .100-inch.

Some uniformly tapering wall cones having the same external dimensions as a DRB 2, .100-inch wall copper cone, have been machined and tested. The wall thickness varies uniformly from .125-inch at a datum .484 inch above the base to .092 inch at a datum 2.875 inches above the base. The average wall thickness is, therefore, slightly heavier than that of the optimum uniform wall cone. The penetration data for the tapered wall cones and for the uniform wall controls are shown in Table V. Inspection data are shown in Table VI. Figures 14 and 15 are typical radiographs of the two types of cones in test assemblies.

A penetration of 17.64 inches of mild steel at 7.5 inches standoff and zero rev/sec is normal for the control round tested, as indicated, without a long spitback tube. The penetration of 19.16 inches, measured for the tapered wall cones, represents a substantial improvement in performance. Since it is not known that the degree of taper employed in this test is optimum, further tests are being planned.

Fig. 14. Radiograph of Tapered-Wall Cone.

Fig. 15. Radiograph of Uniform-Wall Cone.

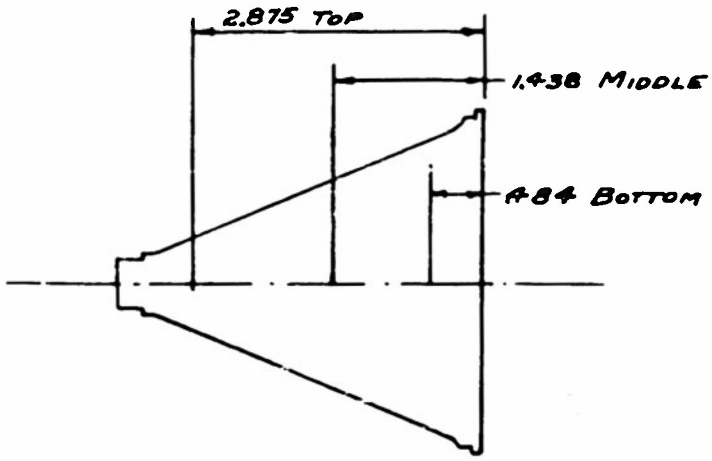
2. A. C. 6366 by T. Nash and A.R. Ubbelohde

Table V
Penetration for Tapered-Wall and Uniform-Wall Cones

Round No.	Lbs. Comp B	Penetration (inches M.S.)	Max. Spread (inches)	Std. Dev. (inches)
Tapered Wall				
FS471	2.52	19.25		
FS472	2.56	19.69		
FS473	2.52	19.56		
FS474	2.56	18.94		
FS475	2.50	18.38		
	Avg.	19.16	1.31	±.53
Uniform Wall				
FS323	2.54	17.94		
FS324	2.54	17.94		
FS325	2.56	17.75		
FS326	2.58	17.81		
FS327	2.54	16.75		
	Avg.	17.64	1.19	±.51

Notes: All rounds assembled in DRC 15 test assemblies, loaded at Ravenna Arsenal, and tested at Erie Ordnance Depot at a standoff distance of 7.5 inches and without rotation.

Table VI
Inspection Data for Tapered-Wall and Uniform-Wall Cones



Round No.	Wall Thickness (in.)			Concentricity	
	Top	Middle	Bottom	Top	Bottom
Uniform Wall					
FS323	.0995	.1000	.1000	.0030	.0025
FS324	.1010	.1010	.1010	.0010	.0010
FS325	.0985	.0985	.0985	.0010	.0010
FS326	.1000	.1005	.1005	.0010	.0010
FS327	.1020	.1005	.1010	.0005	.0005
Tapered Wall					
FS471	.092	.113	.1250	.0005	.0005
FS472	.091	.112	.1252	.0010	.0010
FS473	.093	.113	.1250	.0030	.0005
FS474	.093	.108	.119	.0015	.0015
FS475	.095	.112	.127	.0045	.0005

Future Program

1. Spitback tube study. Thirty rounds having various spitback tubes are on hand at Erie Ordnance Depot.

2. Penetration tests with T-171 bodies.

3. Effect of target material upon penetration.

4. Penetration versus standoff for 45° and 20° copper cones at a constant H.E. head of 3.63 inches.

FUZES

HEAT Fuzing

Tests on T-222 E3 Fuze System

Two tests on the functioning of the T-222 E3 Fuze Systems (T-222 E3 Nose Element and T-208 Base Element) were run at the Erie Ordnance Depot. The rounds were inert loaded and were equipped with spotting charges.

The first program involved the firing of ten projectiles through a two inch bursting screen. The first and seventh rounds of the group were not observed to function. The spotting charge flashes in the functioning rounds varied from a bright light for 10 or 15 seconds to no visible indication other than the base plug of the T-138 E57 projectile being blown off the body. Table VII is a copy of the firing record.

The second program covered the firing of ten projectiles assembled the same as those for the preceding program. The difference between the two tests was that a 1/4-inch steel plate was placed in front of the bursting screen in the second test. The first round of this group missed the target. The remaining nine rounds functioned on impact with the bursting screen. Table VIII is a copy of the firing record.

Discussion

The tee assembly of these rounds was identical to the assembly used in the T-138 E57 HEAT rounds now in pilot production. The wiring through the body of the shell, however, was not identical in that the wire was brought out of the rear of the charge at an intermediate point between the body wall and the T-208 base element instead of at a point adjacent to the wall. The lot number of the base elements was PAE 8410.

HE Fuzing

Tests on T-267 Electrical HE Fuze (DRB 429)

As reported in the Eighteenth Progress Report, eighteen T-267 pyrotechnic test assemblies were made. These were similar to the complete base element, but in the interest of economy the set back mechanism was omitted since the test was designed to test the various pyrotechnic explosive trains. These assemblies were loaded and twelve were statically fired at Picatinny Arsenal in February. The assemblies were then shipped to Erie Ordnance Depot, but were mislaid in transit so that an examination of the assemblies was not completed until the month of April.

Six of the assemblies had the T-18 detonator and the EX-9 primer-delay arranged with the explosive ends flush (See Figure 16). These six assemblies failed to fire the T-18 detonator when the EX-9 primer-delay was functioned.

Six assemblies had the T-18 detonator staggered in the rotor with respect to the EX-9 primer delay (See Figure 17). Five of these pyrotechnic trains functioned while one failed to function.

The remaining six assemblies were held in reserve for possible future tests. However, because of the large size of the T-267 E1 assembly, it will probably be dropped in favor of the E-11 series which appears to be better.

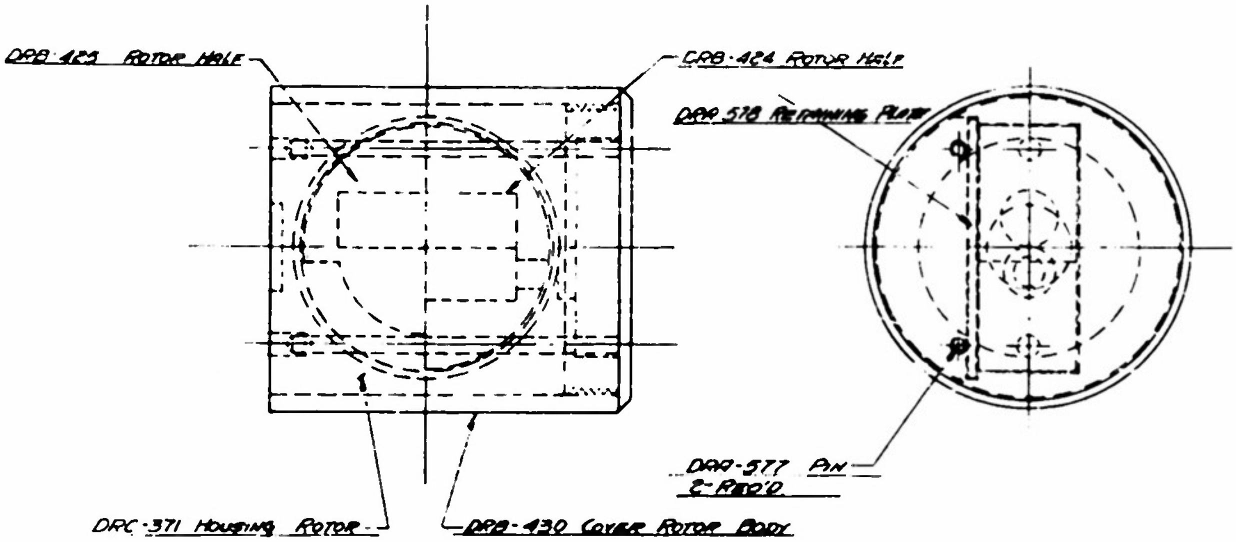


Fig. 16. First Arrangement.
Explosive ends of detonator and primer-delay flush.

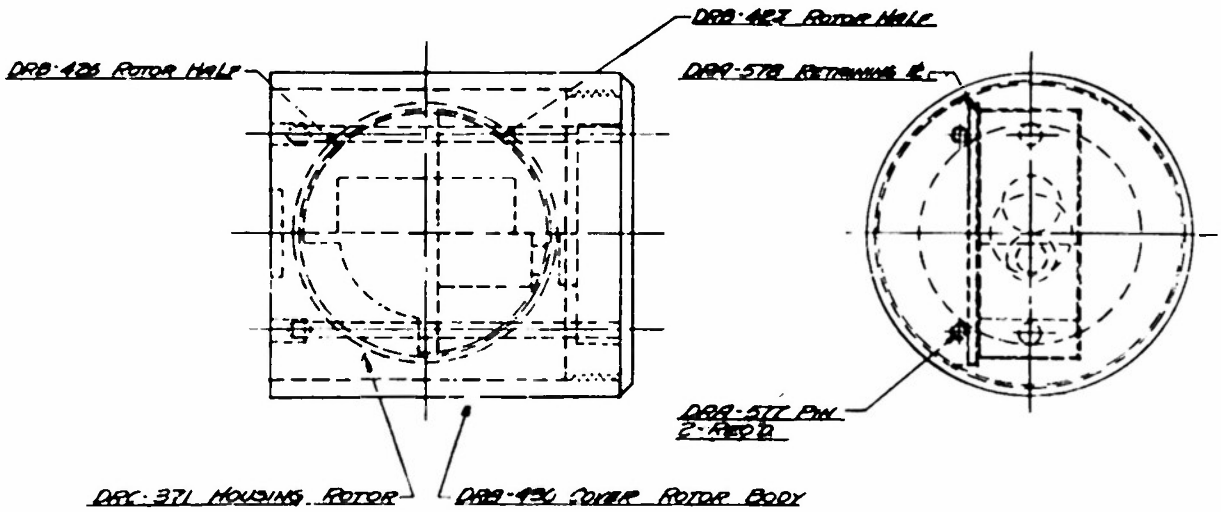


Fig. 17. Second Arrangement.
Detonator staggered in rotor with respect to primer-delay.

Table VII
Firing Record
To test T-222 E3 Fuze System
2-inch bursting screen

Time:
Start. ______
Stop. ______

Date April 10, 11 1952 Program Supplementary II Special Fuze Test

PROJECTILE
Model T-138
Type E57A
Weight (Nominal) 17.5 lb.
C.G. Location 5.25 in from base.
Bourrelet Dia (Nom.) ______
Special Features T-222 E3 Fuze System
T-208 Base Element
2 Spotting Charges

TEMPERATURE
Magazine · Max. 70°F
Min 69°F
Pres. 70°F

TEST GUN
Model T-19 - 14° breech
Type 105 mm Recoilless
Length of Tube 86 in.
Twist of Rifling 1-200 Thin Wall
Sighting Equipment M17 Adapted Telescope
Bore Dia. (Lands) 4.134 in.

MISCELLANEOUS DATA
Range Pendulum Mount; Bursting Screen of 2"x6" planks
Propellant
Type M10 MP web: .0385 in. Charge Wt. 8 lb. 8 oz.
PA 30239 Primer - M57
Proof Director E. Huffman
Observers W. Davies, H. Paton

Round No.	Body No.	Band Type	Powder Charge lb - oz	Wind Vel. & Dir.	Chamber Pressure (Piezo)	Muzzle Velocity Instr.	Muzzle Velocity Actual	Elev. (mils)	Azimuth (mils)	Position of Hit Vert.	Position of Hit Horiz.	Corrected Position of Hit - mils Vert.	Corrected Position of Hit - mils Horiz.	Bourrelet Diameter Front	Bourrelet Diameter Rear	Clearance Front	Clearance Rear	Observations
2121 - 1*	999	B-360-3	8 - 8		—													Did not function - no trace on bursting screen
2122 - 2*	1141	B-406	8 - 8		—													Functioned and spotted
2123 - 3*	—	B-360-3	8 - 8		—													Functioned and spotted clearly
2124 - 4	—	B-360-3	8 - 8		—													Functioned and spotted
2125 - 5	—	B-406	8 - 8		11,130													Functioned and spotted.
2126 - 6	1157	B-406	8 - 8		10,100													Functioning evident on bursting screen, white cloud noticed at bursting screen - did not spot.
2127 - 7	1359	B-360-3	8 - 8		—													Did not function - no trace on bursting screen.
2128 - 8	—	B-406	8 - 8		—													Functioning evident on bursting screen - did not spot.
2129 - 9	1360	B-406	8 - 8		10,070													Functioned and spotted clearly
2130 - 10	—	B-360-3	8 - 8		—													Functioned and spotted clearly. This round was shorted out on initial assembly when the contact terminal in base element was driven forward. Condition corrected and then it was reassembled.

* Fired April 10th - Gage #106 used for pressures.
April 11th - Gage #105 used for pressures 8 out of 10 functioned.
c = .0696 g.f No recoil obtained 6 out of 10 spotted.
Reinforced T6 cases used, T6 polyethylene liners, powder poured in base of case. Round loaded as a unit.

Center of Impact ______
Probable Error - Vertical ______
Probable Error - Horizontal ______

Signed - M.F. Toohig.

Table VIII
Firing Record
To test T-222 E3 Fuze System
¼-inch steel plate in front of bursting screen

Date April 14, 1952 Program Supplementary II Special Fuze Test

Time: Start: ____ Stop: ____

PROJECTILE

Model T-138
Type E57A
Weight (Nominal) 17.6 lb.
C.G. Location 5.34 in from base
Bourrelet Dia (Nom.) 4.132 ·002 in.
Special Features T222 E3 Fuze System
T208 E7 Base Element
2 spotting charges, one charge containing an extra tetryl pellet

TEMPERATURE

Storage Mag Max 71°F
Min 67°F
Pres 70°F
Loading Room 68°F

TEST GUN

Model T19, 14" breech
Type 105 mm recoilless
Length of Tube 85 in. Thin Wall
Twist of Rifling 1-200
Sighting Equipment M17 Adapted Elbow Telescope
Bore Dia. (Lands) 4.134 in.

MISCELLANEOUS DATA

Range Pendulum Mount - Bursting Screen
Propellant
Type M10 MP web .0335 in Charge Wt. 8 lb 8 oz
PA 30239 Primer M57
Proof Director E. Huffman
Observers Davies, Russell

Round No.	Time of Flight	Powder Depth (in)	Powder Charge	Rotating Band	Chamber Pressure	Muzzle Velocity Instr.	Muzzle Velocity Actual	Elev. (mils)	Azimuth (mils)	Position of Hit Vert.	Position of Hit Horiz.	Corrected Position of Hit – mils Vert.	Corrected Position of Hit – mils Horiz.	Bourrelet Diameter Front	Bourrelet Diameter Rear	Clearance Front	Clearance Rear	Thickness of metal + 2 in. of planking
2131-1		3¼	8-8		Piezo None Obtained				Missed bursting screen.									0
2132-2		3½	8-8						Functioned - good spot.									1/16 in
2133-3		2¾	8-8						Functioned - good spot.									¼ in
2134-4		3¾	8-8						Functioned - smaller spot.									¼ in
2135-5		3½	8-8						Functioned - good spot.									¼ in
2136-6		3½	8-8	B-360-3					Functioned - good spot									¼ in
2137-7		3¾	8-8	B-360-3					Functioned - good spot									¼ in
2138-8		3½	8-8	B-360-3					Functioned - good spot									
2139-9		3½	8-8	B-360-3					Functioned - no spot, left clean splatter on screen, tec ¼ in out of correct position, shouldered on plaster									¼ in
2140-10		3½	8-8	B-406					Functioned - good spot.									1/16 in

1 Bursting screen consisted of 2 in x 6 in planking faced with two layers of sheet metal, one about 1/16 in thick and the other 3/16 in. thick
2 Reinforced T6 cases used, T6 polyethylene liners, powder poured into base of liner.
3 Round loaded as a unit
4 Gage #105 used, G = 508 lb/di coulomb

Center of Impact ____
Probable Error - Vertical ____
Probable Error - Horizontal ____

Signed - M F Toohig

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